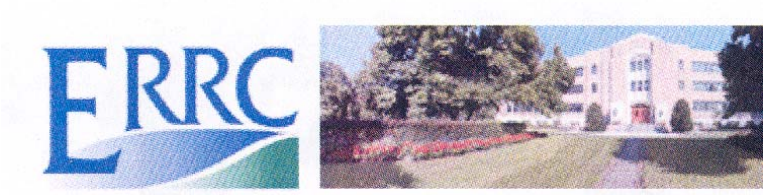

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Behavior of *Listeria monocytogenes* Inoculated on Cantaloupe Surfaces and Efficacy of Washing Treatments To Reduce Transfer from Rind to Fresh-Cut Pieces†

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ABSTRACT

Attachment and survival of *Listeria monocytogenes* on external surfaces (rind) of inoculated cantaloupe, resistance of the surviving bacteria to chlorine or hydrogen peroxide treatments, transfer of the pathogen from unsanitized and sanitized rinds to fresh-cut tissues during cutting and growth, and survival of *L. monocytogenes* on fresh-cut pieces of cantaloupe were investigated. Surface treatment with 70% ethanol to reduce the native microflora on treated melon, followed by immersion in a four-strain cocktail of *L. monocytogenes* (10^8 CFU/ml) for 10 min, deposited 4.2 $\log_{10}$ CFU/cm^2 and 3.5 $\log_{10}$ CFU/cm^2 of *L. monocytogenes* on treated and untreated cantaloupe rinds, respectively. *L. monocytogenes* survived on the treated or untreated cantaloupe rinds for up to 15 days during storage at 4 and 20°C, but populations declined by approximately 1 to 2 $\log_{10}$ CFU/cm^2. Fresh-cut pieces prepared from inoculated whole cantaloupes stored at 4°C for 24 h after inoculation were positive for *L. monocytogenes*. Washing inoculated whole cantaloupes in solutions containing 1,000 ppm of chlorine or 5% hydrogen peroxide for 2 min at 1 to 15 days of storage at 4°C after inoculation resulted in a 2.0- to 3.5-log reduction in *L. monocytogenes* on the melon surface. Fresh-cut pieces prepared from the sanitized melons were negative for *L. monocytogenes*. After direct inoculation onto fresh-cut pieces, *L. monocytogenes* survived, but did not grow, during 15 days of storage at 4°C. Growth was evident by 4 h of storage at 8 and 20°C. It is concluded that sanitizing with chlorine or hydrogen peroxide has the potential to reduce or eliminate the transfer of *L. monocytogenes* on melon surfaces to fresh-cut pieces during cutting.

Listeria monocytogenes is a particular food safety concern because it is widespread in the environment *(6, 10)*, grows under refrigerated conditions, and is a frequent resident in certain food processing establishments *(8, 15)*. The ability of *L. monocytogenes* to attach to a variety of surfaces *(28, 31)* and its virulence characteristics also contribute to this concern. *L. monocytogenes* has been implicated as a causative agent of several foodborne outbreaks, which have resulted in both human illness and death *(16, 30)*. The microorganism has been isolated from soil, sewage sludge, vegetation, and water *(11, 12)* and therefore has the potential to contaminate cantaloupe surfaces.

Many vegetables, including bean sprouts, cabbage, cucumber, potatoes, and radishes, have been found to be contaminated with *L. monocytogenes (2, 6, 11, 12, 17, 18)*. Wong et al. *(43)* detected *L. monocytogenes* in 12.2% of vegetable samples examined. An outbreak attributed to the consumption of contaminated coleslaw *(34)* and a multistate seed sprout recall due to potential contamination with *L. monocytogenes* have occurred. In December 2000, a salad factory in Georgia recalled fresh-cut fruit salad from stores in Georgia, Tennessee, and Alabama because of possible contamination with *L. monocytogenes (21)*, and in March 2001 there was a recall of fresh-cut apple slices because of possible contamination with *L. monocytogenes*. Even though there are no documented reports of an outbreak of human listeriosis associated with the consumption of contaminated fresh-cut cantaloupe, the potential for such an outbreak remains a concern. Sporadic illnesses have been linked with *Listeria ivanovii (34)* and one case of meningitis with *Listeria seeliger (30)*, but *L. monocytogenes* remains the major pathogen to humans.

The attachment of bacteria to surfaces has been documented extensively, although the mechanism of attachment is not fully understood *(8, 20, 35)*. It has also been shown that bacteria attached to cantaloupe surfaces *(40, 41)* and other solid surfaces *(6, 8, 20, 26, 37)* are difficult to inactivate or remove using chemical sanitizers. In this study, we investigated the attachment and survival of *L. monocytogenes* inoculated on the surfaces of untreated cantaloupe or cantaloupe treated with 70% ethanol (EtOH) to reduce the native background microflora. Also, inactivation or removal of the attached bacteria from the cantaloupe surfaces using chlorine and hydrogen peroxide sanitizers was investigated. The efficacy of the sanitizer treatments in reducing transfer of the pathogen from the cantaloupe rinds to the fresh-cut pieces during cutting and the ability of *L. monocytogenes* to grow on inoculated fresh-cut pieces when stored at 4°C was also investigated.

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MATERIALS AND METHODS

Preparation of bacterial inoculum. A mixed bacterial cocktail containing four strains of *L. monocytogenes* (Scott A, ATCC 15313, H7778, and CCR1-L-G) from the U.S. Department of Agriculture, Agricultural Research Service, Eastern Regional Research Center culture collection was cultured by two successive loop transfers at 18-h intervals (37°C) in 5 ml of Trypticase soy broth (Difco Laboratories, Detroit, Mich.) supplemented with 0.6% yeast extract (Difco). A final transfer of 0.2 ml was made into 20 ml of this broth with incubation at 36°C for 18 h under static conditions. The bacterial cells were harvested by centrifugation (10,000 × *g*, 5 min) at 4°C. The cell pellets were washed twice in salt peptone (0.85% NaCl, 0.05% Bacto Peptone [Difco]), and the cell pellets were transferred to 3 liters of 0.1% peptone water (inoculum cocktail). The final bacterial concentration in the inoculum containing the mixed cocktail was 8.58×10^8 CFU/ml as determined by plating serial dilutions on tryptic soy agar (Difco) with incubation at 37°C for 24 h.

Inoculation of whole cantaloupe surfaces. Cantaloupes purchased from a local wholesale distribution center were placed on a laboratory bench top for approximately 18 h to allow the cantaloupes to come to room temperature (~20°C). The whole cantaloupes were divided into two groups: one group was surface treated with 70% EtOH and the other half were left untreated. The treatment with EtOH was accomplished by submerging the cantaloupes in 70% EtOH solution for 1 min, and then treated cantaloupes were placed inside a biosafety cabinet for 1 h to dry. This was done to investigate the effect of a reduced population of native microflora on the attachment of *L. monocytogenes* to cantaloupe rind. A preliminary study was performed to investigate the influence of inoculum concentration on bacterial attachment to the cantaloupe surfaces by submerging whole cantaloupes (alcohol treated and untreated) in *L. monocytogenes* inoculum for 10 min. *L. monocytogenes* inoculum was prepared as stated above, and the final bacterial concentration in the mixed cocktail ranged from 10^3 to 10^9 CFU/ml as determined by plating serial dilutions on tryptic soy agar with incubation at 37°C for 24 h. Based on the results, all cantaloupes in subsequent experiments were submerged in 3 liters of bacterial inoculum containing 10^8 CFU/ml and agitated by stirring with a glove-covered hand for 10 min to ensure even inoculation. After inoculation, the cantaloupes were allowed to dry for 1 h in a biosafety cabinet and then stored at 20 or 4°C for up to 15 days before washing treatments were applied.

Washing treatments. Three wash treatments were compared: sterile tap water, 1,000 ppm of chlorine, and 5% hydrogen peroxide. The 1,000 ppm of chlorine solution was prepared by diluting Clorox commercial bleach containing 5.25% NaOCl in sterile deionized water and adjusting the pH to 6.4 ± 0.1 by adding citric acid (Mallinckrodt, Paris, Ky.). Free chlorine in the solution was determined with a chlorine test kit (Hach Co., Ames, Iowa) that has been approved by the U.S. Environmental Protection Agency. A 5% hydrogen peroxide solution was prepared from a 30% stock solution (Fisher Scientific, Suwanee, Ga.) by dilution with sterile tap water. All washing treatments were performed by submerging the melons at 0, 1, 3, 6, 9, or 15 days after inoculation under the surface of the wash solution, rotating by hand to ensure complete coverage and contact of surfaces with solution for 2 min. Washed melons were allowed to dried for 1 h in a biosafety cabinet before microbiological analysis or fresh-cut preparation.

Microbiological analyses. Whole cantaloupe surfaces receiving washing treatments and those not washed were randomly cut with a sterilized stainless steel cork borer to produce rind plugs of 22 mm in diameter with a surface area (πr^2) of 3.80 cm^2. The rind (40) plugs were blended (Waring commercial blender, speed set at level 5 for 1 min) with 75 ml of 0.1% peptone water. Serial dilutions were prepared in 0.1% peptone water and aliquots (0.1 ml) were plated on brain heart infusion agar (Difco) with incubation at 35°C for 24 h for the enumeration of total mesophilic aerobes. Potato dextrose agar (Difco) acidified with 10% tartaric acid to pH 3.5 with incubation at 25°C for 5 days was used to enumerate yeast and mold. For *L. monocytogenes, Listeria* identification agar (PALCAM, Sigma Chemical Co., St. Louis, Mo.) containing *Listeria* selective supplement (L-4660, Sigma) was used with incubation at 37°C for 48 h *(24, 25)*. All plating was done in duplicate. In addition, pure cultures of *L. monocytogenes* were surface plated onto PALCAM agars to serve as references for identification. Representative presumptive colonies of *L. monocytogenes* were subjected to analysis by use of API *Listeria* test kits (bioMerieux, Marcy l'Etiole, France) for confirmation.

Transfer of *L. monocytogenes* from the rind to the flesh during cutting and growth on fresh-cut pieces. Inoculated and uninoculated cantaloupes stored at 4°C, with or without prior storage and washing treatments, were cut into four sections using a sterile knife. Each section was further cut and the rinds carefully removed. Approximately 100 g of the interior flesh was placed in a stomacher bag with 200 ml of UVM broth (Difco) and pummeled for 30 s in a stomacher (model 400, Dynatech Laboratories, Alexandria, Va.) at medium speed followed by incubation at 35°C for 24 h. A 1-ml aliquot of the UVM broth culture was added to 9 ml of Fraser broth (Difco) and incubated at 35°C for 24 h. The Association of Official Analytical Chemists–approved *Listeria* Rapid Test (Oxoid, Ogdenburg, N.Y.) was used to test for the presence of *L. monocytogenes* in the broth culture before or after addition of selective enrichment. Also, samples were plated (0.1 ml/plate) on PALCAM and modified Oxford (Oxoid) selective agar media.

Growth of *L. monocytogenes* on fresh-cut cantaloupe tissues. In experiments designed to study growth of *L. monocytogenes* on fresh-cut cubes, melon flesh from uninoculated cantaloupes surface sanitized by dipping in chlorine or hydrogen peroxide solution for 5 min was cut into approximately 3-cm cubes using a sterilized stainless steel knife. The fresh-cut pieces were inoculated by immersion in a *L. monocytogenes* cocktail (10^6 CFU/ml) for 30 s. The inoculated fresh-cut cubes were placed in sterile stomacher bags and incubated at 4, 8, or 20°C for up to 15 days. Populations of *L. monocytogenes* recovered from the inoculated fresh-cut pieces were determined by plating (0.1 ml/plate) on PALCAM. The initial inoculum level on the pieces was 3.5 log CFU/g.

Statistical analyses. All experiments were done in triplicate with duplicate samples analyzed at each sampling time. Data were subjected to the Statistical Analysis System (SAS Institute Inc., Cary, N.C.) for analysis of variance and the Bonferroni least significant difference method to determine if there were significant differences ($P < 0.05$) between mean values of number of cells recovered after each treatment.

RESULTS AND DISCUSSION

Effect of EtOH treatment on native microflora on cantaloupe rind. The population of total mesophilic aerobes on cantaloupe rinds ranged from 5.84 to 6.48 $\log_{10}$ CFU/cm^2, and the yeast and mold population ranged from 1.89 to 2.09 $\log_{10}$ CFU/cm^2. Treating whole cantaloupe sur-

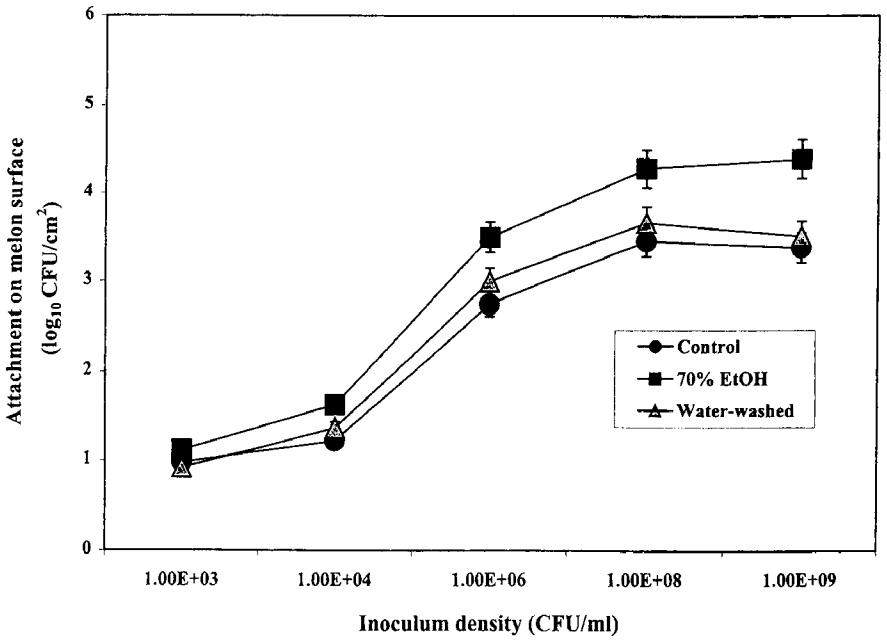

FIGURE 1. *Influence of inoculum size and EtOH treatment on attachment of* L. monocytogenes *to the surface of whole cantaloupe melon. Values represent means ± SE of three separate experiments with duplicate samples per treatments.*

faces with 70% EtOH for 1 min reduced the population of aerobic mesophiles by approximately 1 log CFU/cm^2, and the numbers were significantly ($P < 0.05$) lower than the untreated melons. Population of yeast and mold reduced by the EtOH treatment was approximately 0.6 log CFU/cm^2 and was not significantly different ($P > 0.05$) from the control. Washing with water did not cause a significant reduction ($P > 0.05$) of the native microflora (<0.5 log CFU/cm^2).

Attachment and survival of *L. monocytogenes* on cantaloupe rind. *Listeria monocytogenes* was not isolated from the surface of the whole cantaloupe purchased from the supermarket before inoculation. The attachment of *L. monocytogenes* on the surface of untreated whole melons or melons treated with water or 70% EtOH as influenced by inoculum density are shown in Figure 1. Treating cantaloupe surfaces with 70% EtOH to reduce the native microflora enhanced the attachment of the pathogen in contrast to the control or those washed with water. The number of bacteria that attached increased with increasing inoculum density up to 10^8 CFU/ml. At an inoculum of 10^8 CFU/ml, the number of pathogens attached on the EtOH-treated melon was significantly ($P < 0.05$) higher than control or those washed with water. Raising the inoculum density further did not lead to an appreciable increase in the population of attached cells. These results were similar to our findings for *Escherichia coli (40)* and *Salmonella* Stanley *(41)*. With an inoculum density of 10^8 CFU/ml, 4.1 log CFU/cm^2 of *L. monocytogenes* were recovered from the cantaloupe rinds treated with 70% EtOH, whereas 3.5 log CFU/cm^2 was recovered from the controlled and water-washed melons. Attachment of *L. monocytogenes* to cantaloupe rind was slightly increased after reducing the population of native microflora by treatment with ethanol. However, it is not clear if this is due to the presence of a finite number of microbial binding sites that are increased in availability after ethanol treatment due to removal of native microflora and/or some chemical or physical changes to the melon surface that are imparted by the ethanol treatment. All EtOH-treated whole cantaloupe surfaces appeared dry and flaky after 1 day storage at 20°C or 3 days at 4°C.

Figure 2 shows changes in population of aerobic mesophiles, yeast and mold, and *L. monocytogenes* on the surface of EtOH-treated or untreated whole cantaloupe during storage at 4 (Fig. 2A) or 20°C (Fig. 2B) for 15 days. For all melons, the populations of aerobic mesophiles and *L. monocytogenes* on the surface of cantaloupe rind both declined, whereas the yeast and mold population increased during storage at 4 and 20°C. The population of native mesophilic aerobes declined by 0.5 to 1.0 log under all four experimental conditions. Numbers of *L. monocytogenes* surviving on the cantaloupe surfaces during storage were not significantly different ($P > 0.05$) between EtOH-treated and untreated melons at either storage temperature. An approximate 1.5- to 2.0-log reduction in the population of *L. monocytogenes* was observed on the melon surface treated with 70% EtOH and a 1.0- to 1.5-log reduction on those not treated at the end of 15 days of storage at 4 or 20°C. However, significant differences ($P < 0.05$) between populations of yeast and mold on melon surfaces stored at 4 and 20°C were observed. Yeast and mold populations gradually increased on both treated and untreated melons during storage at 4 and 20°C for up to 15 days, with an overall increase of approximately 1.0 and 2.5 log at 4 and 20°C, respectively. Francis and O'Beirne *(13)* reported growth of *Listeria innocua* on lettuce that had been dipped in chlorine and had a reduced population of native microflora. This was not observed on cantaloupe rind when the initial population of native microflora was reduced by treatment with EtOH. The slight increase in the population of yeast and mold on melon surfaces could have resulted from a slight amount of moisture retained after inoculation even after the 1-h drying period. The increased yeast and mold population on the melon surface may have outcompeted *L. monocytogenes* for colonizable space and available nutrients, thus resulting in the observed decline of *L. monocytogenes* at both storage temperatures.

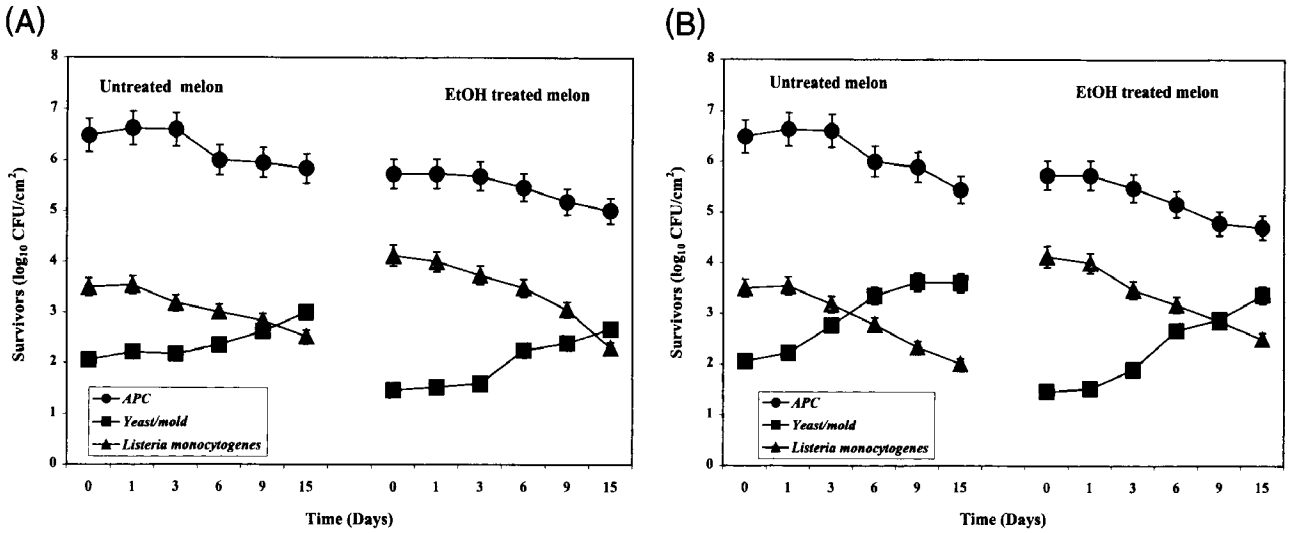

FIGURE 2. *Survival of native aerobic mesophilic bacteria, yeast and mold, and* L. monocytogenes *on the surface of untreated or EtOH-treated whole cantaloupe melon stored at 4 (A) or 20°C (B) for up to 15 days. Values represent means ± SE of three separate experiments with duplicate samples per treatments.*

L. monocytogenes and the native mesophilic aerobes showed a slightly more rapid decline on melons stored at 20°C for 15 days (Fig. 2B) compared with melons stored at 4°C (Fig. 2A). This may have been due to the ability of *L. monocytogenes* to grow at 4°C, giving this bacterium a competitive advantage over native aerobic mesophilic bacteria. It is possible that the native microflora of cantaloupe, especially the yeast and mold population, may have interfered with survival or growth of *L.. monocytogenes.* Previous studies have reported antagonism by native microflora against *L. innocua* on shredded lettuce *(22).* However, reducing the initial population of the native microflora on whole cantaloupe surfaces before inoculating with *L. monocytogenes* by EtOH treatment did not allow for growth of *L. monocytogenes* under all four treatment conditions.

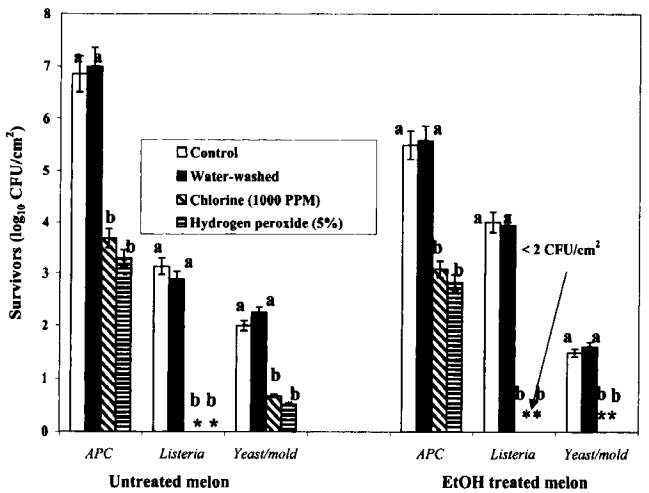

FIGURE 3. *Effect of washing treatments on aerobic mesophiles, yeast and mold, and* L. monocytogenes *on the surface of whole cantaloupes stored at 4°C for 24 h after inoculation. Asterisk indicates below level of detection (2 CFU/cm^2). Values represent means ± SE of three separate experiments with duplicate samples per treatments. Means not followed by the same letters are significantly different (P < 0.05) from each other by the Bonferroni least significant difference method.*

Effect of washing treatments. The effect of washing treatments on total mesophilic aerobes, yeast and mold, and *L. monocytogenes* on the surfaces of whole cantaloupe stored at 4°C for 24 h is shown in Figure 3. Washing with water did not cause a significant ($P < 0.05$) reduction of native microflora or *L. monocytogenes.* However, chlorine and hydrogen peroxide treatments did cause a significant ($P < 0.05$) reduction of native microflora and *L. monocytogenes.* Chlorine or hydrogen peroxide treatments reduced the native population of mesophilic aerobes by approximately 3 log_{10} CFU/cm^2 and yeast and mold by 1.5 log for EtOH-treated and untreated melons. Both treatments also were equally effective in reducing *L. monocytogenes.* The surviving population of *L. monocytogenes* on all cantaloupe surfaces was below the detection limit (2 CFU/cm^2) following the chlorine or hydrogen peroxide washes (a 3- to 4-log reduction). The effect of the various washes against the microbes after more prolonged storage of inoculated melons, as seen in Figures 4 and 5, was similar to Figure 3. As noted previously, washing with water did not cause a significant ($P < 0.05$) reduction of native microflora or *L. monocytogenes,* but chlorine and hydrogen peroxide treatments did. Differences noted after 5 and 15 days of storage (Figs. 4 and 5, respectively) were as follows: (i) at days 5 and 15 the chlorine and the hydrogen peroxide washes did not completely eliminate yeast and mold and (ii) *L. monocytogenes* was more susceptible to removal by washing with water, especially at day 15. Populations of *L. monocytogenes* did not become more difficult to reduce with time of storage after inoculation. Previously, we reported the inability of chlorine or hydrogen peroxide treatments to significantly reduce attached *Salmonella* Stanley *(41)* or *E. coli (40)* on cantaloupe rind after 3 days or more of storage at 4°C after inoculation.

Chlorination of wash water to prevent microbial contamination in produce processing lines is commonly used *(5, 44),* but the formation of potentially carcinogenic chlorinated organic compounds is a concern *(42).* The use of

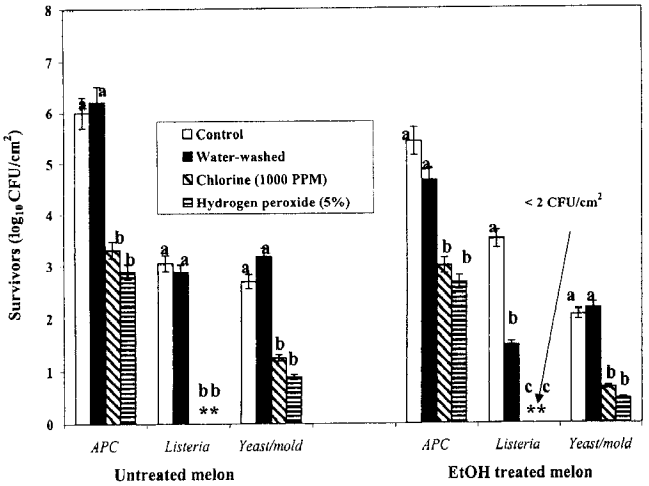

FIGURE 4. *Effect of washing treatments on aerobic mesophiles, yeast and mold, and* L. monocytogenes *on the surface of whole cantaloupes stored at 4°C for 5 days after inoculation. Asterisk indicates below level of detection (2 CFU/cm^2). Values represent means ± SE of three separate experiments with duplicate samples per treatments. Means not followed by the same letters are significantly different (P < 0.05) from each other by the Bonferroni least significant difference method.*

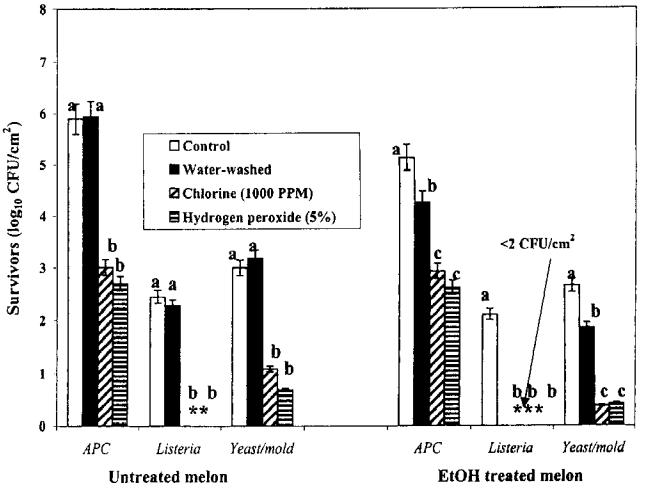

FIGURE 5. *Effect of washing treatments on aerobic mesophiles, yeast and mold, and* L. monocytogenes *on the surface of whole cantaloupes stored at 4°C for 15 days after inoculation. Asterisk indicates below level of detection (2 CFU/cm^2). Values represent means ± SE of three separate experiments with duplicate samples per treatments. Means not followed by the same letters are significantly different (P < 0.05) from each other by the Bonferroni least significant difference method.*

alternative sanitizers, such as hydrogen peroxide, might be desirable to decontaminate cantaloupe surfaces before fresh-cut preparation *(4)*. Efficacy of hydrogen peroxide in preservation of fresh-cut melon *(33)* and vegetables *(19)* and for washing of fresh mushrooms *(32)* has been reported. The results of this study suggest that a hydrogen peroxide treatment to decontaminate cantaloupe surfaces before fresh-cut preparation was comparable to that of a high level of chlorine.

Growth and survival of *L. monocytogenes* on fresh-cut pieces. Minimally processed fresh fruits and vegetables often provide a good substrate for microbial growth *(27, 29)*. Readily available nutrients may allow proliferation of human pathogenic organisms such as *L. monocytogenes* on fresh-cut melon. In our study, *L. monocytogenes* directly inoculated on fresh-cut pieces of cantaloupe survived, but did not grow, during storage at 4°C for up to 15 days. Growth was evident at higher storage temperatures (Fig. 6). There was a lag time of 4 h before observing growth in fresh-cut samples stored at 20°C and 6 h for fresh-cut pieces stored at 8°C. Populations in fresh-cut pieces stored at 8 or 20°C increased by 1 log unit, reaching 4.86 log CFU/g by the end of storage. Earlier studies have shown that *L. monocytogenes* is capable of growing on fresh-cut apple slices *(9)* and several vegetables *(1, 3, 7, 22, 36, 38, 39)* stored under controlled or uncontrolled atmosphere conditions. Our study indicates that the pathogen has the ability to grow on fresh-cut cantaloupe at abusive temperatures. This finding is similar to our earlier studies *(41)*, where we reported growth of *Salmonella* Stanley on cantaloupe fresh-cut pieces stored 20°C or higher for more than 6 h.

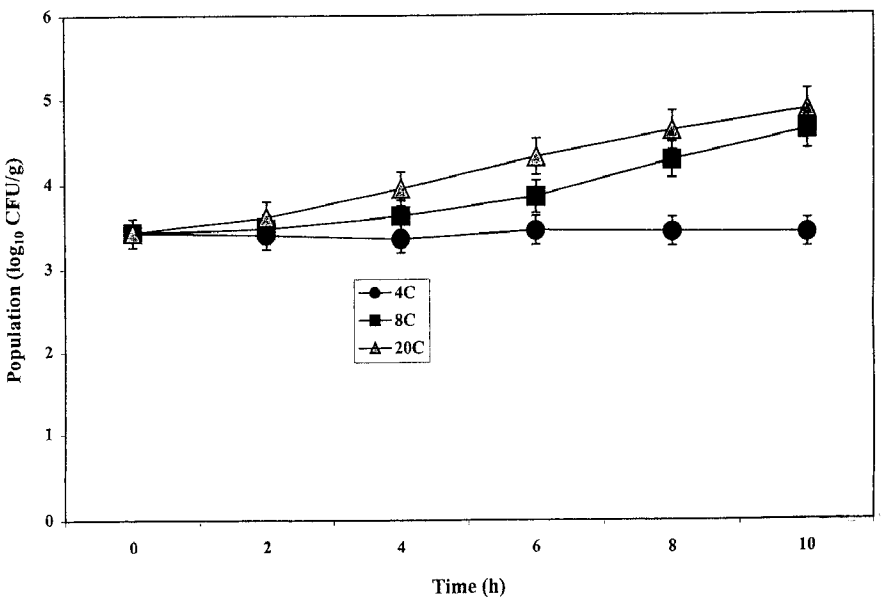

FIGURE 6. *Growth and survival of* L. monocytogenes *on the surface of directly inoculated fresh-cut cantaloupe during storage at 4, 8, or 20°C for up to 10 h. Values represent means ± SE of three separate experiments with duplicate samples per treatments.*

TABLE 1. *Effect of inoculum load on the transfer of* L. monocytogenes *from whole cantaloupe surfaces to fresh-cut pieces when prepared 24 h after inoculation*[a]

	Population on fresh-cut tissues		
	Direct plating[b]		
Initial inoculum level (log_{10} CFU/cm^2)	No. positive	Log_{10} CFU/g	Positive by enrichment
2.16 ± 0.06	1/3	0.23 ± 0.03	3/3
3.26 ± 0.13	3/3	0.54 ± 0.02	ND[c]
3.98 ± 0.15	3/3	1.31 ± 0.07	ND
4.52 ± 0.09	3/3	1.46 ± 0.10	ND

[a] Values represent mean ± SD of data from three trials and duplicate samples per trial.
[b] Detection limit was 2 CFU/g.
[c] ND = not determined.

Transfer of *L. monocytogenes* to fresh-cut pieces during cutting. Results of experiments on the transfer of *L. monocytogenes* from the rind to the melon flesh during fresh-cut preparation are shown in Table 1. Two of three samples of fresh-cut pieces prepared from whole cantaloupe inoculated to give a *L. monocytogenes* population of 2.16 log CFU/cm^2 on the rind plugs were negative for the pathogen even after enrichment. When the population of *L. monocytogenes* on the rind plugs was 3.26 log CFU/cm^2 or above, the pathogen was recovered from all samples of the fresh-cut pieces without enrichment. The results of this study suggest that transfer of the pathogen from the rind to fresh-cut pieces may occur on a fairly consistent basis if the number of *L. monocytogenes* on the rind is 2 log CFU/cm^2 or more. Previously, we reported recovery of *Salmonella* Stanley from fresh-cut pieces prepared from cantaloupe inoculated at 10^3 CFU/cm^2 of rind or above *(41)*. Gayler et al. *(14)* showed that the interior tissue of watermelon could be contaminated if *Salmonella* was present on either the rind of the watermelon or the knife used for slicing. They failed to report the initial inoculum size or the final population attained on the watermelon flesh. Similarly, transfer of *Salmonella* from the surface of tomatoes to the interior during cutting has been reported *(23)*. Their data suggested that the rate of bacterial transfer depends on inoculum size on the stem scar.

Table 2 shows recovery of *L. monocytogenes* from fresh-cut pieces prepared from washed or unwashed cantaloupes stored at 4°C for up to 15 days after inoculation. *L. monocytogenes* was recovered from fresh-cut pieces prepared from all control or water-washed cantaloupes up to 24 h after inoculation. At 5 days after inoculation, fresh-cut pieces prepared from one of three melons for the control or the water-washed treatment were positive after enrichment for the pathogen. However, fresh-cut pieces prepared from the control or water-washed melons 10 or 15 days after inoculation were negative for the pathogen. All samples of fresh-cut pieces prepared from the melons washed with chlorine or hydrogen peroxide were negative for the pathogen after enrichment irrespective of time of washing and fresh-cut preparation following days of postinoculation.

TABLE 2. *Recovery of* L. monocytogenes *on fresh-cut pieces prepared from washed or unwashed cantaloupes during storage at 4°C for up to 15 days after inoculation*[a]

	Samples positive by enrichment (days of storage after inoculation)				
Treatments	0	1	5	10	15
Control	3/3	3/3	1/3	0/3	0/3
Water washed	3/3	3/3	1/3	0/3	0/3
Chlorine (1,000 ppm)	0/3	0/3	0/3	0/3	0/3
Hydrogen peroxide (5%)	0/3	0/3	0/3	0/3	0/3

[a] Initial inoculum level on the rinds was 3.5 log CFU/cm^2. Experiments were replicated three times.

The data suggest that sanitation of cantaloupe surfaces used for fresh-cut preparation can help to ensure microbiological safety of fresh-cut melons.

In conclusion, *L. monocytogenes* did not grow on inoculated cantaloupe rinds under all conditions tested. Pathogen populations gradually declined, but survivors were detected after 15 days of storage at 4 or 20°C. Sanitizing whole cantaloupe surfaces with chlorine (1,000 ppm) and hydrogen peroxide (5%) appears effective in reducing *L. monocytogenes,* mesophilic aerobes, and yeast and mold, resulting in 2.0- to 3.5-log reductions of *L. monocytogenes* under the various experimental conditions. The effectiveness in reducing the population of *L. monocytogenes* is not dependent on the length of storage after inoculation and before treatment. Treatment of cantaloupe surfaces with 70% EtOH was not an effective means of sanitizing cantaloupe surfaces. Transfer of *L. monocytogenes* from the inoculated rind to the interior flesh during preparation of fresh-cut pieces was demonstrated. Sanitizing whole cantaloupe surfaces with chlorine and hydrogen peroxide at the level used in the study can greatly reduce or eliminate this transfer. Once present on fresh-cut pieces, *L. monocytogenes* appears capable of surviving long-term storage (5 days) at 4°C.

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